

# MME



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## ELECTRICAL ENGINEERING BRANCH



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DESIGNERS & MANUFACTURERS OF ELECTRONIC INSTRUMENTATION

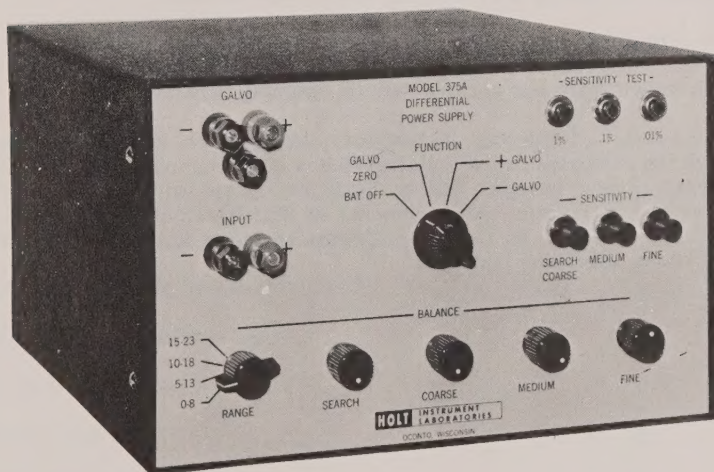
## ELECTRICAL ENGINEERING BRANCH



**OPERATING AND SERVICING  
MANUAL**

**FOR**

**DIFFERENTIAL POWER SUPPLY  
MODEL 375A**



**THIS MANUAL TO ACCOMPANY  
INSTRUMENT NO. . . . .**

**OCTOBER 1968**

**HOLT INSTRUMENT LABORATORIES**

**OCONTO, WISCONSIN**

## CLAIM FOR DAMAGE IN SHIPMENT

The instrument should be tested as soon as it is received. If it fails to operate properly, or it is damaged in any way, a claim should be filed with the carrier. Also, notify Holt Instrument Laboratories or the local representative immediately. A full report of the damage should be obtained by the claim agent and this report should be forwarded to us. We will advise you of the disposition to be made of the equipment and arrange for repair or replacement. Include model number and serial number when referring to this instrument for any reason.

## WARRANTY

Holt Instrument Laboratories warrants each instrument manufactured by them to be free from defects in material and workmanship. Our liability under this warranty is limited to servicing or adjusting any instrument returned to the factory for that purpose and to replace any defective parts thereof. Electron tubes, fuses, and batteries are specifically excluded from any liability. This warranty is effective for one year after delivery to the original purchaser when the instrument is returned, transportation charges prepaid, and when upon our examination it is to our satisfaction defective. If the fault has been caused by misuse or abnormal conditions of operation, repairs will be billed at cost. In this case, an estimate will be submitted before the work is started.

If any fault develops, the following steps should be taken:

1. Notify either the factory or the area Holt representative, giving full details of the difficulty, and include the model and serial numbers. Upon receipt of this information we will give you service data or shipping instructions.
2. On the receipt of shipping instructions, forward the instrument prepaid to the factory or the authorized repair station indicated in the instructions. If requested, an estimate of the charges will be made before the work begins if such work is not covered by warranty. All shipments of Holt Instrument Laboratories' equipment should be packed in a strong exterior container surrounded by two or three inches of shock absorbing material.

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Functional block diagram and schematic diagram of Model 375A are bound at the back of the manual.

# SECTION 1

## INTRODUCTION

### 1.1 General Description

a. The Holt Model 375A Differential Power Supply in conjunction with a suitable Thermal Converter and a sensitive galvanometer is a simple, accurate, RMS responding AC-DC comparator.

b. The Model 375A includes the galvanometer switching circuitry and the balancing emf circuitry. The balancing emf is variable from 0 mv. to 20 mv. in four ranges. This coverage is sufficient for use with all of the commonly used Thermal Converters containing thermoelements.

c. The Model 375A also includes galvanometer sensitivity keys which provide three degrees of sensitivity in 20:1 steps and three sensitivity test keys of 1%, 0.1%, and 0.01% which allow the operator to quickly determine the galvanometer sensitivity.

### 1.2 Operational Environment

The unit will operate normally after thermally stabilizing over the following range of environmental conditions:

a. Temperatures from + 4 degrees Centigrade to + 40 degrees Centigrade.

b. Relative humidity from 0 to 90 percent.

c. Altitude from 0 to 10,000 feet above sea level.

### 1.3 Non-operational Environment

The unit will operate normally after being subjected to the following conditions followed by a suitable thermal stabilizing time interval:

a. Stored up to 48 hours at temperatures not exceeding - 55 degrees Centigrade.

b. Stored up to 48 hours at temperatures not exceeding + 60 degrees Centigrade.

c. Stored up to 48 hours at altitudes not exceeding 40,000 feet above sea level.

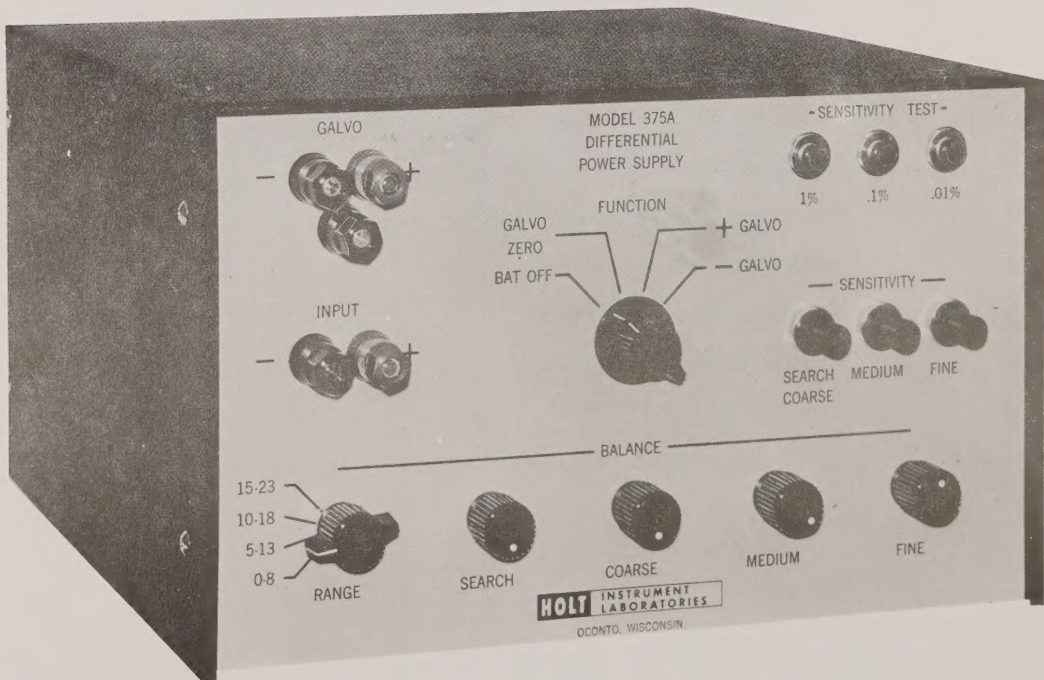


Figure 1. Holt Model 375A Differential Power Supply

## TECHNICAL SPECIFICATIONS

|                        |                                                                          |
|------------------------|--------------------------------------------------------------------------|
| Output Voltage         | 0 to 20 MV                                                               |
| Balance Controls       | Search, Coarse, Medium, Fine                                             |
| Resolution             | 0.002% of full range                                                     |
| Power                  | Replaceable Mercury Cell                                                 |
| Terminals              |                                                                          |
| Galvanometer           | 3 5-way binding posts                                                    |
| Input                  | 2 5-way binding posts                                                    |
| Galvo Sensitivity Keys | Search-Coarse, Medium, Fine                                              |
| Galvo Calibration Keys | 0.01%, 0.1%, 1%                                                          |
| Function Switch        | Battery off, Galvo Zero,<br>+ Galvo, - Galvo                             |
| Operating Environment  | Temperature + 4 to 40° C.<br>Humidity 0-90% RH<br>Altitude 0-10,000 feet |
| Weight                 | 10 lbs.                                                                  |
| Mechanical             | 11-3/4" W x 11-1/2" L x 7" H                                             |

## SECTION 2

# OPERATING INSTRUCTIONS

### 2.1 Preparation for Use

a. General. The Model 375A Differential Power Supply is supplied factory tested and calibrated. The unit is ready to operate from its internal mercury cell battery of 14,000 MAH to provide up to 1,500 hours of reliable operation.

### 2.2 Applications

The Model 375A was designed as a source of balancing emf for use with thermoelement Thermal Converters. This AC-DC Comparator system is capable of measuring or standardizing AC potentials or currents with a high degree of certainty. The Thermal Converter may consist of a thermoelement module with the appropriate multiplier resistor modules to cover the required range of potentials.

Alternately, it may consist of the thermoelement module and the appropriate shunt resistor modules to cover the required range of currents. The uncertainty in measuring or standardizing to a given AC potential or current is dependent upon the traceability of the Thermal Converter, the uncertainty introduced in measuring the DC potential or current determined equal to the AC potential or current being measured or standardized, and the care exercised in constructing an AC-DC Comparator system to insure freedom from ground loops and external electrostatic or electromagnetic contributions.

a. Measuring or Standardizing AC Potentials. The thermoelement module used should have an output emf between 0 and 20 mv. The indicating galvanometer should be of the electronic type with an input impedance greater than 200 ohms and a sensitivity consistent with the required resolution. A DC voltage source with ppm resolution, volt-box, potentiometer, and standard cell are required for measurements of lowest uncertainty. The volt-box, potentiometer, and standard cell can be deleted if a calibrated DC voltage source is used, but there will be a corresponding increase in the measurement uncertainty.

b. Measuring or Standardizing AC Currents. The thermoelement module used should have an output emf between 0 and 20 mv. The indicating galvanometer should be of the electronic type with an input impedance greater than 200 ohms and a sensitivity consistent with the required resolution. A DC current source with ppm resolution, appropriate standard resistor, potentiometer, and standard cell are required for measurements of lowest uncertainty. The standard resistor, potentiometer and standard cell can be deleted if a calibrated DC current source is used, but there will be a corresponding increase in the measurement uncertainty.

### 2.3 Interconnection

Figures 3 and 4 illustrate typical interconnections for the measurement of AC potentials and currents, respectively. The Input and Galvanometer terminals of the Model 375A are special gold-plated 5-way binding posts designed for low-microvolt operation. Solid-copper leads should be used to connect the Model 375A to the thermoelement module and the Galvanometer. The lead ends should be cleaned free of any oxide coating and securely tightened under the terminals to insure that the thermal emf's generated at these connections will be negligible. Lead pairs should be twisted to exclude electromagnetic interference and shielded to exclude electrostatic interference. The stability of the galvanometer indication will be influenced by any thermal emf's generated in the above connection. The use of banana plug connections or spade lug connections is not recommended. If ordinary tinned leads are used, it is recommended that they be securely tightened under the Model 375A terminals.

### 2.4 Operating Controls

The controls and terminals located on the front panel are described below. These are used in the normal operation of the Model 375A. There are no controls or adjustments located inside the instrument.

a. GALVO Terminals. The GALVO (galvanometer) terminals are located at the upper left corner of the front panel. The emf present across the + and - terminals is representative of the difference between the Thermal Converter output emf and the internal balancing emf. The third terminal is a chassis connection useful for shielding the galvanometer leads. If the galvanometer used has a "guard" terminal it should also be connected to this Model 375A chassis connection. The considerations set forth in Paragraph 2.3 must be observed to assure drift free operation. The positive galvanometer input lead should be connected to the terminal marked + and the negative galvanometer input lead should be connected to the terminal marked -.

b. INPUT Terminals. The INPUT terminals located near the upper left corner of the front panel accept the output emf of the Thermal Converter. The considerations set forth in Paragraph 2.3 must be observed to assure drift free operation. The positive thermoelement output lead should be connected to the terminal marked + and the negative thermoelement output lead should be connected to the terminal marked -.

c. FUNCTION Switch. This switch located in the middle of the front panel controls the battery circuit and the galvanometer circuit. In the OFF

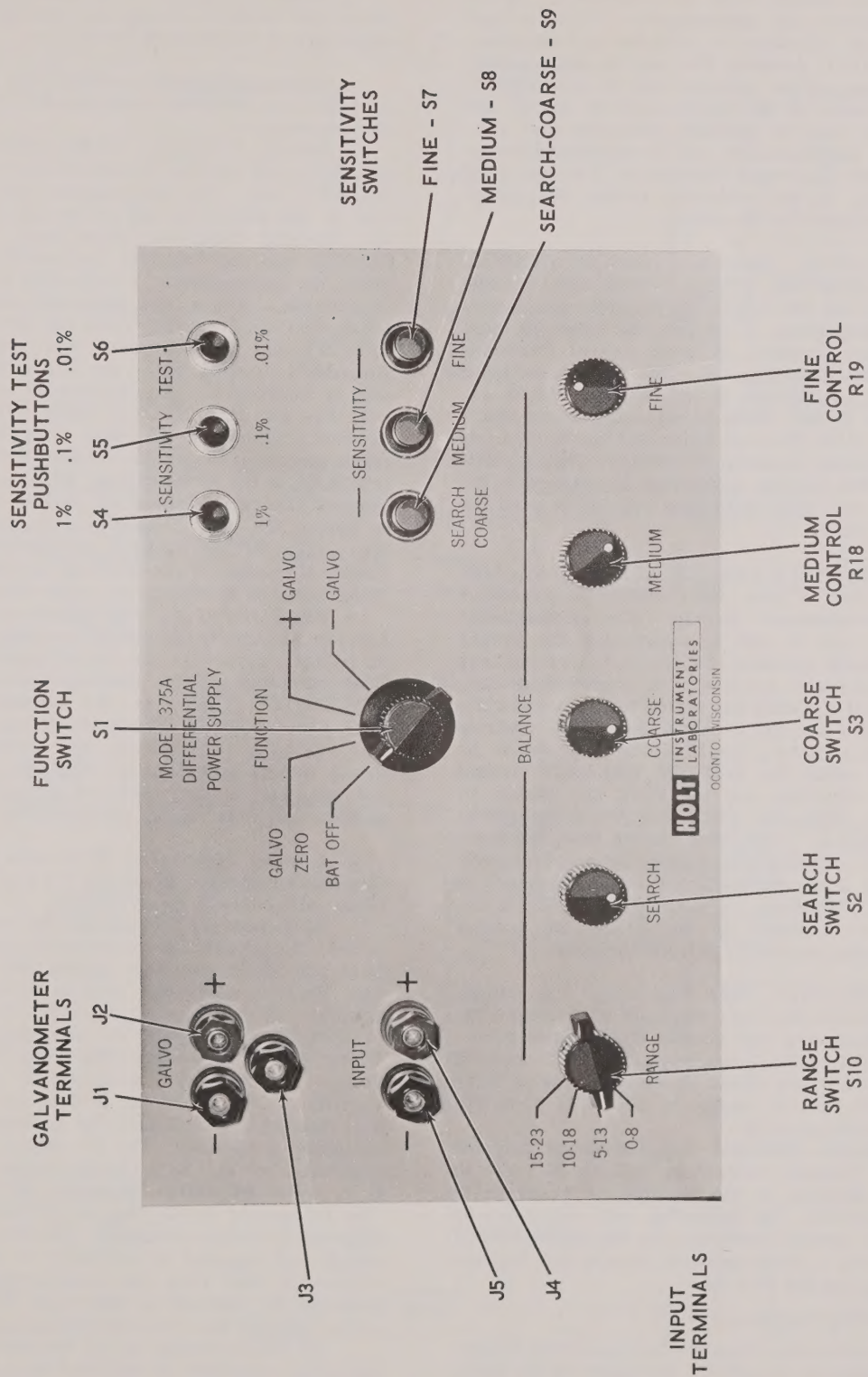


Figure 2. Front Panel Terminals and Controls

position, the Model 375A is inoperative. In the ZERO position, the galvanometer circuit is open to allow the operator to zero the galvanometer. In the +GALVO position, the balance emf circuitry is operative and the galvanometer is connected to swing up-scale if the thermoelement output emf is greater than the internal balancing emf, provided the galvanometer and thermoelement connections are made per Paragraphs 2.4a and 2.4b. Alternately, in the -GALVO position the galvanometer response is reversed.

d. **BALANCE Controls** (RANGE, SEARCH, COARSE, MEDIUM, FINE). These five controls located across the bottom of the front panel control the magnitude of the internal balancing emf. A clockwise rotation of each control increases the internal balancing emf. The RANGE switch is calibrated in millivolts to aid the operator in selecting the proper range of balancing emf to match the output of the Thermal Converter thermoelement. The remaining controls (SEARCH, COARSE, MEDIUM, FINE) provide continuous adjustment of the balancing emf with increasing resolution over the indicated range.

e. **SENSITIVITY Keys** (SEARCH-COARSE, MEDIUM, FINE). These keys control an attenuator in the galvanometer circuit. The galvanometer sensitivity can be set by depressing the proper key. A slight clockwise twist acts to lock the keys in the depressed position. In normal operation, the SEARCH-COARSE key should be depressed while the SEARCH and the COARSE BALANCE controls are being adjusted, the MEDIUM key should be depressed while the MEDIUM BALANCE control is being adjusted, and the FINE key should be depressed while the FINE BALANCE control is being adjusted. This may not be true, however, if the basic galvanometer sensitivity is not properly chosen or if the galvanometer input impedance is less than 200 ohms. If more than one key is depressed at a time, the key giving the greater galvanometer sensitivity will predominate.

f. **SENSITIVITY TEST Keys** (1%, 0.1%, 0.01%). The SENSITIVITY TEST keys act to decrease the internal balancing emf so that the resulting galvanometer deflection is the same as would occur if the heater current of the Thermal Converter thermoelement were to change by 1%, 0.1%, or 0.01%, respectively.

The Model 375A was designed specifically for use with Thermal Converters utilizing thermoelements. Because of the square-law response of thermoelements, the balancing emf decreases by twice the amount indicated by the SENSITIVITY TEST keys. The operator should not depress more than one key at a time.

## 2.5 Operating Technique

a. **Connections.** Connect the output of the Thermal Converter to the INPUT terminals of the Model 375A. Connect the input of the galvanometer to the GALVO terminals of the Model 375A. For each of these connections observe the considerations set forth in Paragraph 2.3.

b. **Range Selection.** Select the proper RANGE BALANCE control setting to correspond to the output emf of the Thermal Converter.

c. **Galvanometer Zero.** Set the FUNCTION switch to ZERO and zero the galvanometer by use of its zero control.

d. **Balance Technique.** Set the FUNCTION switch to +Galvo and depress the SEARCH-COARSE SENSITIVITY key. The galvanometer will then indicate if the balancing emf is greater or less than the Thermal Converter output emf. Adjust the SEARCH and the COARSE BALANCE controls to bring the galvanometer's deflection as near zero as possible. Repeat this procedure with the MEDIUM BALANCE control while the MEDIUM SENSITIVITY key is depressed and with the FINE BALANCE control while the FINE SENSITIVITY key is depressed. If a balance is not obtainable with the SEARCH-COARSE SENSITIVITY key depressed, either the Thermal Converter's output leads are reversed or the RANGE BALANCE control is set to the wrong setting. When using thermoelement Thermal Converters having output emf's in excess of 7 mv., it may be necessary to change the setting of the RANGE BALANCE control to obtain a balance if the Thermal Converter is not being operated at 100% of its rated current.

e. **Sensitivity Test.** To determine the galvanometer sensitivity (deflection resulting from change of heater current in the thermoelement Thermal Converter) the operator need only depress the proper SENSITIVITY TEST key (for example, the 0.1% key), observe the resulting galvanometer deflection (for example, 10 division), and divide the offset (0.1%) by the deflection (10 divisions). The table and example on page 2-5 are included to aid the operator in determining galvanometer sensitivity.

f. **General Techniques.** When used in an AC-DC Comparator system, the Model 375A operating technique will generally be as follows:

(1) **Measuring Unknown AC Potentials or Currents.** The proper thermoelement module and multiplier or shunt resistor module will be chosen. The Thermal Converter will be energized by the unknown AC potential or current. A balance will be obtained by following the procedure set forth in Paragraphs 2.5b through 2.5e. The Thermal Converter will then be energized by a source of variable DC potential or current and this source will then be adjusted until the galvanometer again indicates a balance. The DC source will then be measured as set forth in Paragraph 2.2, or if it is a calibrated source its output will be recorded. The DC source should then be reversed and again adjusted to obtain a balance. The above procedure should be repeated as necessary to eliminate the affects of drift from the measurement. The AC potential or current is then equal to the average of the +DC and the -DC recorded values.

(2) **Standardizing an AC Potential or Current.** Here the procedure is reversed from that set forth in Paragraph 2.5f(1). The Model 375A is balanced while the DC potential or current is applied to the Thermal Converter and the AC potential or current is adjusted to give the same balance.

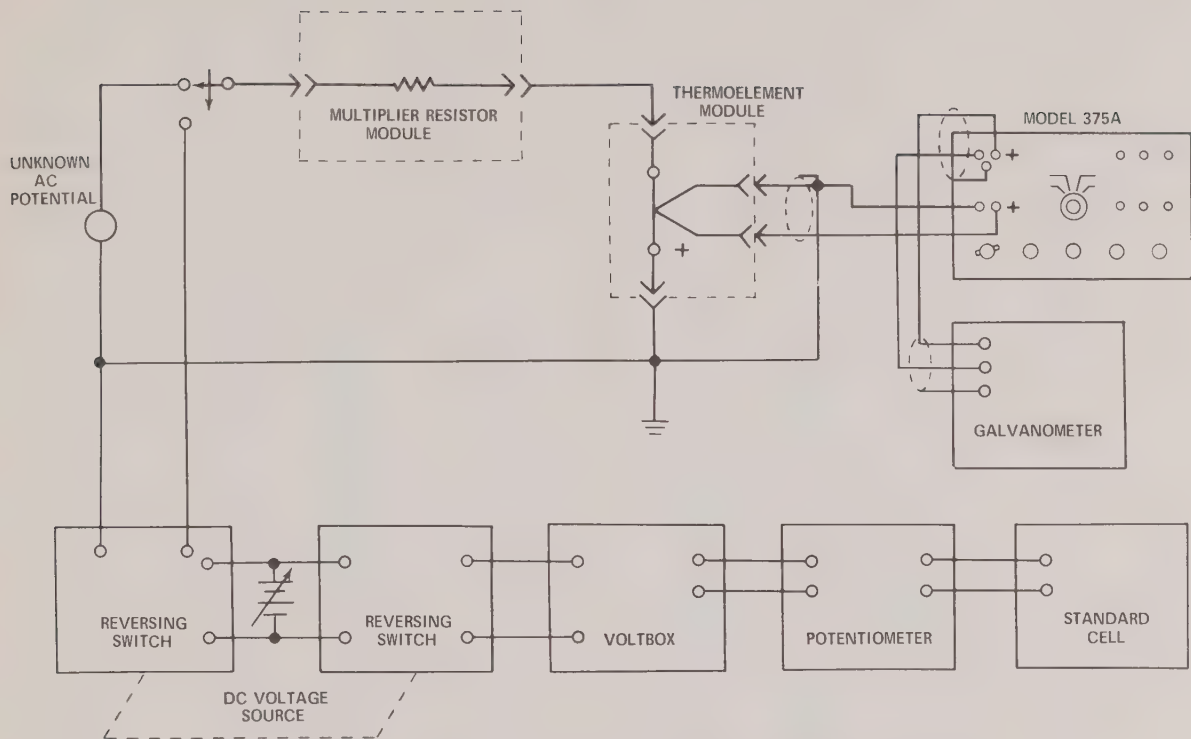


Figure 3. AC Potential Measurements

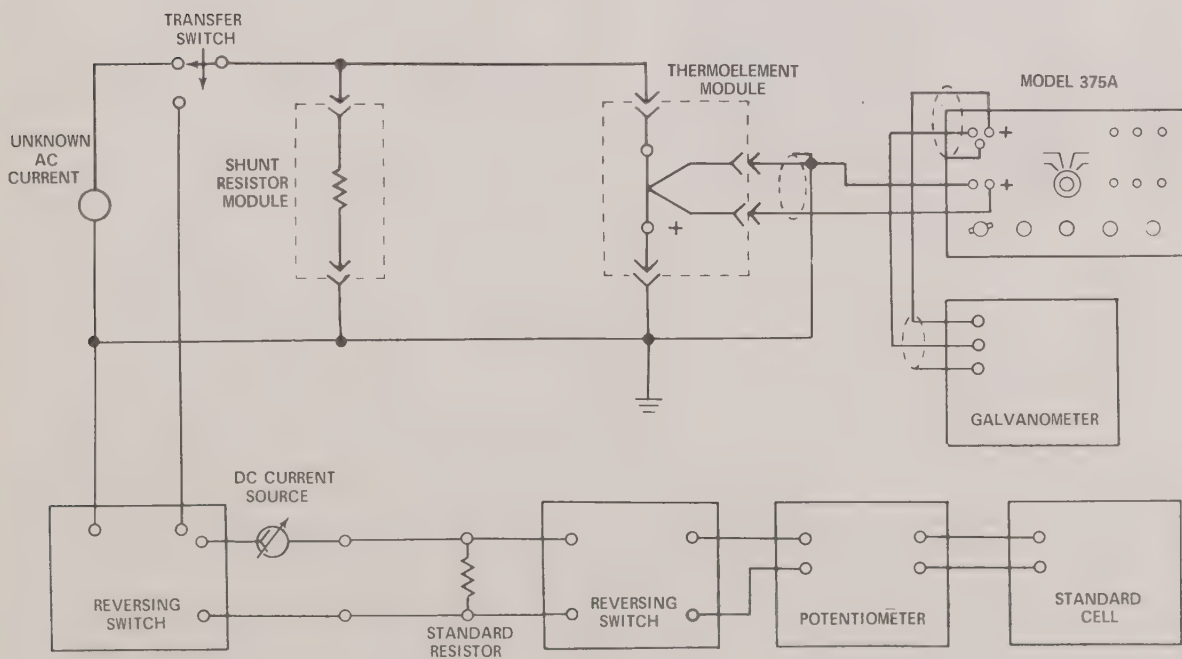


Figure 4. AC Current Measurements

Table I. Percent Resolution Per Meter Division

Sensitivity Test Key (%) — % Resolution  
Resultant Galvanometer — Division  
Deflection (Divisions)

| Meter Deflection (Divisions) | Resolution (%/Division) |        |         |
|------------------------------|-------------------------|--------|---------|
|                              | 1%                      | 0.1%   | 0.01%   |
| 1                            | 1.0                     | .1     | .01     |
| 2                            | .05                     | .05    | .005    |
| 3                            | .033                    | .033   | .0033   |
| 4                            | .025                    | .025   | .0025   |
| 5                            | .02                     | .02    | .002    |
| 6                            | .0167                   | .0167  | .00167  |
| 7                            | .0143                   | .0143  | .00143  |
| 8                            | .0125                   | .0125  | .00125  |
| 9                            | .0111                   | .0111  | .00111  |
| 10                           | .01                     | .01    | .001    |
| 11                           | .091                    | .0091  | .00091  |
| 12                           | .083                    | .0083  | .00083  |
| 13                           | .077                    | .0077  | .00077  |
| 14                           | .071                    | .0071  | .00071  |
| 15                           | .067                    | .0067  | .00067  |
| 16                           | .0625                   | .00625 | .000625 |
| 17                           | .0588                   | .00588 | .000588 |
| 18                           | .0555                   | .00555 | .000555 |
| 19                           | .0525                   | .00525 | .000525 |
| 20                           | .05                     | .005   | .0005   |
| 21                           | .0475                   | .00475 | .000475 |
| 22                           | .0455                   | .00455 | .000455 |
| 23                           | .0435                   | .00435 | .000435 |
| 24                           | .0417                   | .00417 | .000417 |
| 25                           | .04                     | .004   | .0004   |

| Meter Deflection (Divisions) | Resolution (%/Division) |        |         |
|------------------------------|-------------------------|--------|---------|
|                              | 1%                      | 0.1%   | 0.01%   |
| 26                           | .0384                   | .00384 | .000384 |
| 27                           | .037                    | .0037  | .00037  |
| 28                           | .0357                   | .00357 | .000357 |
| 29                           | .0344                   | .00344 | .000344 |
| 30                           | .0333                   | .00333 | .000333 |
| 31                           | .0323                   | .00323 | .000323 |
| 32                           | .0312                   | .00312 | .000312 |
| 33                           | .0303                   | .00303 | .000303 |
| 34                           | .0294                   | .00294 | .000294 |
| 35                           | .0286                   | .00286 | .000286 |
| 36                           | .0278                   | .00278 | .000278 |
| 37                           | .027                    | .0027  | .00027  |
| 38                           | .0263                   | .00263 | .000263 |
| 39                           | .0256                   | .00256 | .000256 |
| 40                           | .025                    | .0025  | .00025  |
| 41                           | .0244                   | .00244 | .000244 |
| 42                           | .0238                   | .00238 | .000238 |
| 43                           | .0233                   | .00233 | .000233 |
| 44                           | .0227                   | .00227 | .000227 |
| 45                           | .0222                   | .00222 | .000222 |
| 46                           | .0217                   | .00217 | .000217 |
| 47                           | .0213                   | .00213 | .000213 |
| 48                           | .0208                   | .00208 | .000208 |
| 49                           | .0202                   | .00202 | .000202 |
| 50                           | .02                     | .002   | .0002   |

Example: Assume you have nulled an unknown voltage and now observe a change of 5 divisions on the meter. To convert this change to percent of the applied voltage, depress the .1% key (assuming you are on the FINE sensitivity range) and note the meter deflection. Assume it is 33 divisions. The formula above gives:

$$\frac{.1\%}{33 \text{ divisions}} = .003\% \text{ per division}$$

The use of Table I gives .00303. Hence the 5 division change originally observed is equal to .00303 x 5 or .015%.

## SECTION 3

### THEORY OF OPERATION

#### 3.1 Basic Circuit Theory

The Model 375A Differential Power Supply consists of a thermoelement emf circuit, a bucking emf circuit, a range emf circuit, a sensitivity test circuit, and a galvanometer attenuator.

a. Thermoelement EMF Circuit. This circuit consists of a thermoelement (TE1) whose heater current is controlled by the SEARCH, COARSE, MEDIUM, and FINE BALANCE controls. As a consequence, its output emf can be varied over the range of approximately 2.0 mv. to 8.5 mv. At the 0-8 mv. setting of the RANGE BALANCE CONTROL the thermoelement output emf is the major portion of the internal balancing emf. Since the Thermal Converter usually contains a thermoelement also, there will exist a considerable amount of freedom from the effects of ambient temperature changes upon the thermoelements because of this differential thermoelement connection.

b. Bucking EMF Circuit. In series with the output of the thermoelement (TE1) is R48 across which can be introduced a slight negative bias or bucking emf to reduce the balancing emf to zero. As the thermoelement (TE1) output emf is ranging from 2.0 mv. to 8.5 mv. the bucking emf is ranging from approximately -4 mv. to 0 mv. Therefore, this balancing emf is varying from -2.0 mv. to 8.5 mv. in the 0-8 range.

c. Range EMF Circuit. In series with the output of TE1 and R48 is R77 across which can

be introduced a positive bias or range emf in fixed steps of approximately 5 mv., and 15 mv. This allows the internal balancing emf to vary over the range of 0 mv. to 23 mv. as shown on the RANGE control.

d. Sensitivity Test Circuit. There are two sensitivity test circuits. One acts to offset the heater current of the thermoelement (TE1). As a SENSITIVITY TEST key is depressed a small amount of current is bypassed around the heater while simultaneously the heater circuit resistance is increased slightly so that the total current flowing through the BALANCE controls does not change. The other sensitivity test circuit acts to offset the bucking emf and the range emf in the same manner as the thermoelement heater current.

e. Galvanometer Attenuator. The galvanometer attenuator consists of the SENSITIVITY keys and their associated resistors. This attenuator is designed to operate with a galvanometer input impedance in excess of 200 ohms. When the FINE SENSITIVITY key is depressed, the galvanometer is connected directly between the Thermal Converter output emf and the internal balancing emf. For the other sensitivities this difference emf is attenuated before being supplied to the galvanometer. There will be a 20:1 increase in sensitivity as the operator goes from SEARCH-COARSE sensitivity to MEDIUM sensitivity. If the galvanometer input impedance is considerably greater than 200 ohms, there will also be a 20:1 increase in sensitivity as the operator goes from MEDIUM to FINE sensitivity.

## SECTION 4 RECALIBRATION

There are no recalibration adjustments to be made on the Model 375A. Recalibration will consist of checking the performance of the instrument in accordance with specifications.

The performance of the Model 375A may be checked using the following suggested test procedure:

### 1. RANGE TESTS:

Connect a DC voltmeter, Fluke Model 883 or equivalent, to the INPUT terminals. Depress and lock down the SEARCH-COARSE and MEDIUM SENSITIVITY buttons. Set the FUNCTION switch to the + GALVO position. Set all BALANCE controls to maximum counterclockwise position.

Check the voltage at the INPUT terminals according to the following table:

| Range Switch Position | All Other Balance | Input Voltage |
|-----------------------|-------------------|---------------|
| 0-8                   | CCW               | < 0 MV        |
| 0-8                   | CW                | > 8 MV        |
| 5-13                  | CCW               | < 5 MV        |
| 5-13                  | CW                | > 13 MV       |
| 10-18                 | CCW               | < 10 MV       |
| 10-18                 | CW                | > 18 MV       |
| 15-23                 | CCW               | < 15 MV       |
| 15-23                 | CW                | > 23 MV       |

### 2. SENSITIVITY TEST PUSHBUTTONS

- a. Set RANGE switch to 15-23 MV.

- b. Set FUNCTION switch to + GALVO.

- c. Set Fluke 883 to 20 MV. Adjust BALANCE controls to null Model 883.

- d. Depress 1% test key. Measure change on Model 883. (320 to 480 microvolts)

- e. Depress the .1% test key. Measure change on Model 883. (32-48 microvolts)

- f. Depress .01% test key. Measure change on Model 883. (3.2 - 4.8 microvolts)

### 3. SENSITIVITY KEYS

- a. Set the RANGE switch to 15-23 position.

- b. Set the FUNCTION switch to + GALVO.

- c. Depress and lock down all three SENSITIVITY keys.

- d. Short the INPUT terminals together.

- e. Monitor the GALVO terminals with a Fluke Model 883 or equivalent meter.

- f. Adjust the BALANCE controls to obtain 20 mv at the GALVO terminals.

- g. Disengage the FINE key. The GALVO voltage should be 1 mv  $\pm$  10%.

- h. Disengage the MEDIUM key. The GALVO voltage should be .050 mv  $\pm$  10%.

These tests indicate that the SENSITIVITY keys and circuitry are changing the voltage delivered to the GALVO terminals in the required steps to result in a smooth progression of a balance adjustment.

## SECTION 5 SERVICING

Careful attention has been given to ease of service. The schematic diagram contains all the necessary information. Voltages are given for a typical set of conditions as an aid in servicing. All component locations are called out in photographs for quick location when a problem is encountered. All replaceable parts are listed in the Replaceable Parts List to allow ordering of damaged components or to order spares. Some must be ordered from Holt Instrument Laboratories because they are not available from any other source.

By using the schematic diagram the Model 375A may be easily serviced by conventional troubleshooting techniques. The thermoelement (TE1) should be treated with care. The heater resistance is a nominal 90 ohms. When measuring this resistance it is very important to limit the current

through the heater to 5 ma. Thus, the method of measuring the heater resistance should not impress more than .5 volt across the heater. Failure to limit the heater current may cause permanent damage to the thermoelement. A similar current limit should be observed when measuring the resistance of the thermocouple. This resistance of the thermocouple is a nominal 16 ohms. A current limiting resistor should be placed in series with the thermocouple when measuring the thermocouple resistance.

The mercury battery in the Model 375A is rated at 14,000 milliampere hours of useful life. In the Model 375A, the useful life is 1,500 hours maximum. Thus, the condition of the mercury battery should be checked periodically.

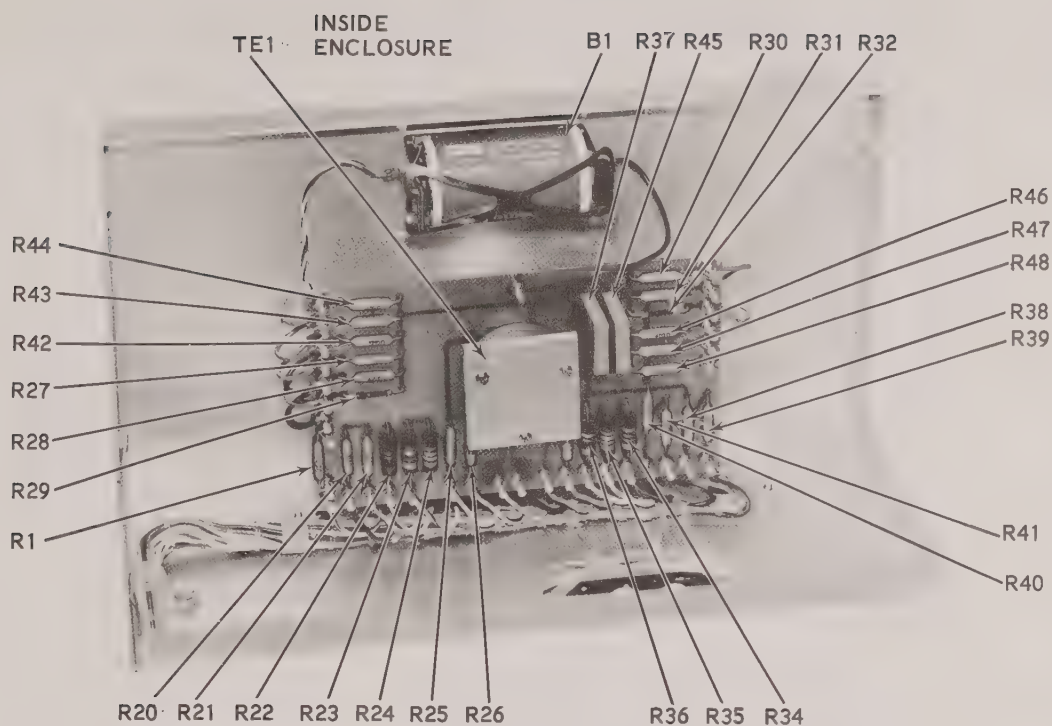


Figure 5. Circuit Board

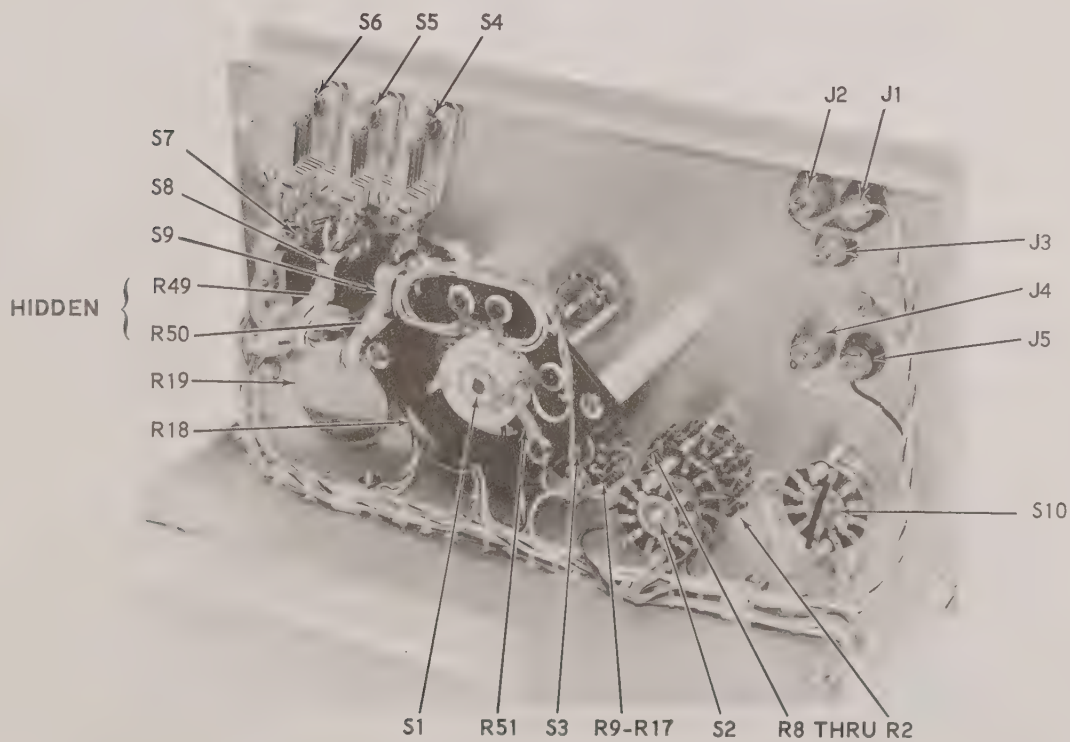


Figure 6. Inside Front Panel

# SECTION 6

## LIST OF REPLACEABLE PARTS

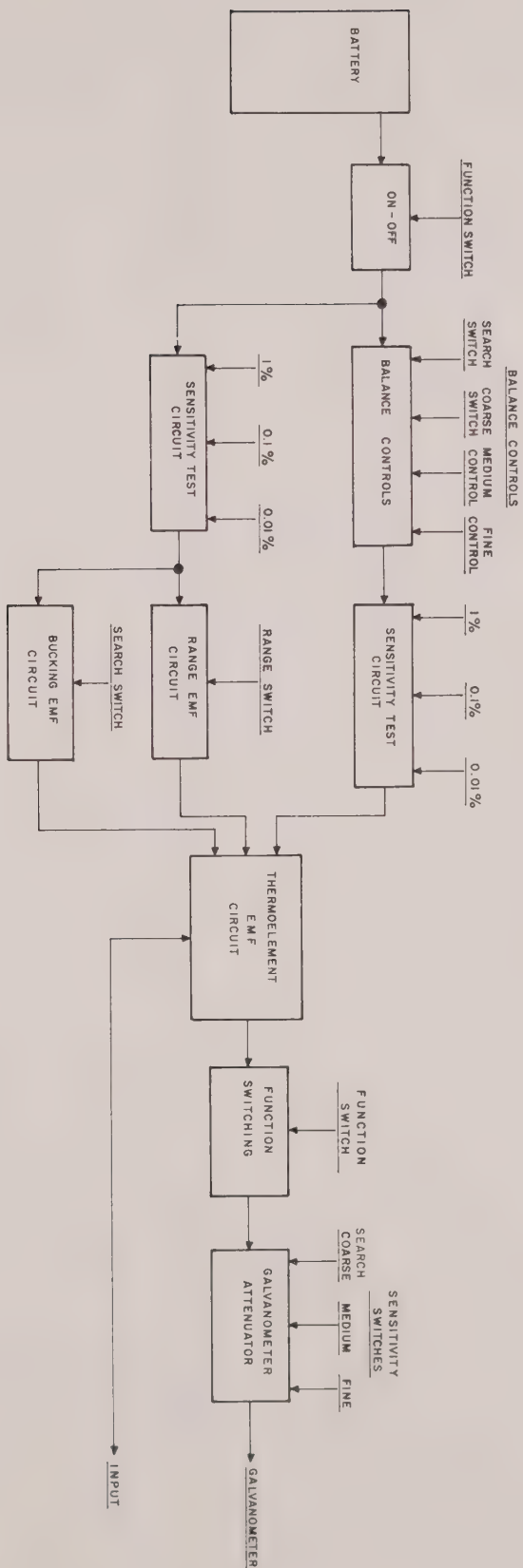
| Circuit Symbol | Description                                   | Holt Part No. | Manufacturer | Catalog Number | Location Figure No. |
|----------------|-----------------------------------------------|---------------|--------------|----------------|---------------------|
| B1             | Battery, Mercury<br>1.35 Volts, 14,000 MAH    | 0601-001      | Mallory      | RM42R          | 5                   |
| J1             | Binding Post, Red                             | 1803-025      | Gen. Cement  | 33-296R        | 2,6                 |
| J2             | Binding Post, Black                           | 1803-024      | Gen. Cement  | 33-296B        | 2,6                 |
| J3             | Binding Post, Black                           | 1803-024      | Gen. Cement  | 33-296B        | 2,6                 |
| J4             | Binding Post, Red                             | 1803-025      | Gen. Cement  | 33-296R        | 2,6                 |
| J5             | Binding Post, Black                           | 1803-024      | Gen. Cement  | 33-296B        | 2,6                 |
| R1*            | Resistor, M.F., 33.2 Ohm, 1/2 Watt, 1%        | 0804-257      | IRC          | CEC-TO         | 5                   |
| R2 thru R8     | Resistor, Composition, 33 Ohm, 1/2 Watt, 10%  | 0801-026      | Allen Brad.  | EB3301         | 6                   |
| R9 thru R17    | Resistor, Composition, 4.7 Ohm, 1/2 Watt, 10% | 0801-219      | Allen Brad.  | EB47G1         | 6                   |
| R18            | Resistor, Variable, 6 Ohms, 3 Watts, WW       | 54998         | Holt         |                | 6                   |
| R19            | Resistor, Variable, 20 Ohms, 3 Watts, WW      | 54997         | Holt         |                | 6                   |
| R20            | Resistor, M.F., 90.9 Ohms, 1/2 Watt, 1%       | 0804-092      | IRC          | CEC-TO         | 5                   |
| R21            | Resistor, M.F., 10 Ohms, 1/2 Watt, 1%         | 0804-232      | IRC          | CEC-TO         | 5                   |
| R22            | Resistor, WW, 2 Ohms, 2 Watts, 10%            | 0802-142      | IRC          | BWH            | 5                   |
| R23            | Resistor, WW, 0.43 Ohm, 2 Watts, 10%          | 0802-140      | IRC          | BWH            | 5                   |
| R24            | Resistor, WW, 0.39 Ohm, 2 Watts, 10%          | 0802-118      | IRC          | BWH            | 5                   |
| R25            | Resistor, M.F., 110 Ohms, 1/2 Watt, 1%        | 0804-322      | IRC          | CEC-TO         | 5                   |
| R26            | Resistor, M.F., 5.9 Megohms, 1/2 Watt, 1%     | 0804-323      | RPC          | HACW           | 5                   |
| R27            | Resistor, M.F., 20 K Ohms, 1/2 Watt, 1%       | 0804-151      | IRC          | CEC-TO         | 5                   |
| R28            | Resistor, M.F., 200 K Ohms, 1/2 Watt, 1%      | 0804-179      | IRC          | CEC-TO         | 5                   |
| R29            | Resistor, M.F., 2 Megohms, 1/2 Watt, 1%       | 0804-324      | RPC          | HACW           | 5                   |
| R30            | Resistor, M.F., 69.8 K Ohms, 1/2 Watt, 1%     | 0804-325      | IRC          | CEC-TO         | 5                   |
| R31            | Resistor, M.F., 698 K Ohms, 1/2 Watt, 1%      | 0804-326      | IRC          | CEC-TO         | 5                   |
| R32            | Resistor, M.F., 6.98 Megohms, 1/2 Watt, 1%    | 0804-327      | RPC          | HACW           | 5                   |

# LIST OF REPLACEABLE PARTS

| Circuit Symbol | Description                               | Holt Part No. | Manufacturer | Catalog Number | Location Figure No. |
|----------------|-------------------------------------------|---------------|--------------|----------------|---------------------|
| R33            | Resistor, M.F., 13 Ohms, 1/2 Watt, 1%     | 0804-279      | IRC          | CEC-TO         | 5                   |
| R34            | Resistor, W.W., 6.8 Ohms, 2 Watts, 10%    | 0802-130      | IRC          | BWH            | 5                   |
| R35            | Resistor, W.W., 0.68 Ohm, 2 Watts, 10%    | 0802-121      | IRC          | BWH            | 5                   |
| R36            | Resistor, W.W., 1 Ohm, 2 Watts, 10%       | 0802-123      | IRC          | BWH            | 5                   |
| R37            | Resistor, W.W., 5 Ohms, 0.1%, 20 ppm/°C   | 0802-431      | ESI          | RC2R           | 5                   |
| R38 thru R41   | Resistor, M.F., 1500 Ohms, 1/2 Watt, 1%   | 0804-121      | IRC          | CEC-TO         | 5                   |
| R42            | Resistor, M.F., 1210 Ohms, 1/2 Watt, 1%   | 0804-119      | IRC          | CEC-TO         | 5                   |
| R43            | Resistor, M.F., 604 Ohms, 1/2 Watt, 1%    | 0804-334      | IRC          | CEC-TO         | 5                   |
| R44            | Resistor, M.F., 402 Ohms, 1/2 Watt, 1%    | 0804-274      | IRC          | CEC-TO         | 5                   |
| R45            | Resistor, W.W., 5 Ohms, 0.1%, 20 ppm/°C   | 0802-431      | ESI          | RC2R           | 5                   |
| R46            | Resistor, M.F., 604 Ohms, 1/2 Watt, 1%    | 0804-334      | IRC          | CEC-TO         | 5                   |
| R47            | Resistor, M.F., 402 Ohms, 1/2 Watt, 1%    | 0804-274      | IRC          | CEC-TO         | 5                   |
| R48            | Resistor, M.F., 1210 Ohms, 1/2 Watt, 1%   | 0804-119      | IRC          | CEC-TO         | 5                   |
| R49            | Resistor, M.F., 82.5 K Ohms, 1/2 Watt, 1% | 0804-167      | IRC          | CEC-TO         | 6                   |
| R50            | Resistor, M.F., 3920 Ohms, 1/2 Watt, 1%   | 0804-132      | IRC          | CEC-TO         | 6                   |
| R51            | Resistor, M.F., 221 Ohms, 1/2 Watt, 1%    | 0804-098      | IRC          | CEC-TO         | 6                   |
| S1             | Switch, Rotary, 3 Pole, 4 Pos.            | 1101-081      | Holt         |                | 2,6                 |
| S2             | Switch, Rotary, 3 Pole, 10 Pos.           | 54989         | Holt         |                | 2,6                 |
| S3             | Switch, Rotary, 1 Pole, 10 Pos.           | 54996         | Holt         |                | 2,6                 |
| S4             | Switch, Momen. Contact, 2 Pole            | 1102-008      | Switchcraft  | FF1006         | 2,6                 |
| S5             | Switch, Momen. Contact, 2 Pole            | 1102-008      | Switchcraft  | FF1006         | 2,6                 |
| S6             | Switch, Momen. Contact, 2 Pole            | 1102-008      | Switchcraft  | FF1006         | 2,6                 |
| S7             | Switch, Low Thermal, 1 Pole, 1 Pos.       | 1102-004      | L & N        | P1123-L        | 2,6                 |

## LIST OF REPLACEABLE PARTS

| Circuit<br>Symbol | Description                         | Holt<br>Part No. | Manufacturer | Catalog<br>Number | Location<br>Figure No. |
|-------------------|-------------------------------------|------------------|--------------|-------------------|------------------------|
| S8                | Switch, Low Thermal, 1 Pole, 1 Pos. | 1102-004         | L & N        | P1123-L           | 2,6                    |
| S9                | Switch, Low Thermal, 1 Pole, 2 Pos. | 1102-005         | L & N        | P1123-S1          | 2,6                    |
| S10               | Switch, Rotary, 2 Pole, 4 Pos.      | 54988            | Holt         |                   | 2,6                    |
| TE1               | Thermoelement, Dual, 5 ma., 7 mv.   | 0401-009         | Holt         |                   | 5                      |



FUNCTIONAL BLOCK  
DIAGRAM OF MODEL 373A









ELECTRICAL ENGINEERING BRANCH



91655